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THE RIVER COUNTIES OF KANSAS.

SOME NOTES ON THEIR GEOLOGY AND MINERAL RESOURCES.

By Robert Hay.

TOPOGRAPHICAL INTRODUCTION.

The counties on the Missouri river are the oldest settled counties in Kansas. In the counties next west and south the phrase "to go to the river" meant to go to Leavenworth, Quindaro, White Cloud, Atchison, or other places where there was a landing place on the Missouri river. From the steamboats on the river came the immigrants and their supplies.

By the construction of the acts of Congress settling the boundary of the state of Missouri, the bed of the great river from the fortieth parallel to the mouth of the Kaw is in Kansas. The east bank is the west line of the state of Missouri.

The windings of the stream make the river front of Kansas of great length. It is not less than 145 miles, of which nearly 20 belong to Wyandotte, 23 to Leavenworth, about 21 to Atchison, and over 80 to Doniphan. If the shores of the permanent islands were included this water frontage would be increased. The front to the river mainly consists of high bluffs, and where there is a broad expanse of bottom land, as at Island creek, Kickapoo, and elsewhere, the bluffs still abruptly bound the river valley, rising steeply from the water or from the fertile alluvia which the water has in time passed deposited against them.

The bluffs are mostly covered with timber, but there are districts in each county where the rocks rise bare and bold, and where the height is increased by precipices of yellow clay which is 20 to 50 feet deep.

The precipitous front to the river is broken in many places by narrow openings which allow the discharge of small tributary streams, and in some places by wider ones, as that of Salt creek, near Fort Leavenworth, and Wolf creek, in Doniphan county. Many of the narrower openings become wider behind the bluffs, which there become narrow ridges, and the ravine-like openings is seen to be the outlet of an amphitheatre which extends north and south and some distance west. This topographical form is noticeable at Atchison and Quindaro, and is more strongly marked at Leavenworth and the Soldiers' Home.

In many parts of the river front the rocky walls are distinctly terraced. Mostly two terraces are well marked, but in many places five can be traced, and some of them can be followed round into the creek valleys and the amphitheatres. These terraces indicate a greater depth and a vastly broader expanse of the waters of the great river in past ages whon it stood at higher levels, while obstructions far to the southeast were being removed.

Wyandotte and Leavenworth counties have a frontage also to the Kaw river of 25 and 22 miles respectively, and the southern Wolf creek and the Stranger there discharge from valleys that cut deep into the table-land. This table-land in Wyandotte and eastern Doniphan counties is scarcely recognizable as such, so numerous are the depressions and so round the elevations; but in the western parts of Doniphan, Atchison and Leavenworth the plateau character is distinctly seen, the level top in many parts being floored with persistent beds of limestone, whose flatness gives a marked difference to the landscape from the large areas which are covered with the yellow clay. At the mouth of the Kaw the water line is just below the elevation contour of 750 feet, and at the Nebraska line the water level is below the 850 foot contour. Yet everywhere within a mile or two of the river the surface rises to over 1,000 feet, and at Pilot Knob in the city of Leavenworth, and another Pilot Knob at.Atchison, the elevation reaches over 1,100 feet. West of the Stranger in Leavenworth and Atchison counties, and in the western part of Doniphan, stretching into Brown county, the plateau keeps the higher elevation.

Where the yellow clay has not covered up the subjacent rocks, there is found in the ampitheatres and other valleys a lower plateau or step to the higher one whose base is of sandstone and of sandy shales, at an elevation from 1,000 feet down to 850 feet, and its curved slopes have more affinity to the yellow clay topography than to the limestones, and hence its character is not as readily detected. It shows, however, very plainly around Leavenworth, and in the valley of the Little Stranger, in the higher lands of Wyandotte county, and far away in Brown county. More details of it will be given further on, and we may speak of it distinctly as the sandstone plateau, or the sandstone horizon.

There is one topographical feature that is important only in limited areas. That is the accumulation of great masses of boulders. Resting on the bed-rock, under the yellow clay, red quartzite, granite, and greenstone boulders, and gravel, may be found nearly everywhere wherever a stream, however small, has cut down to the older formations. This may be seen within the limits of Kansas City, at Leavenworth, Atchison, Muncie, and elsewhere. On the Missouri front the boulders are, however, very rare, though they are frequently abundant in ravines only a few rods within the bluffs. Though widely distributed, they only prominently mark the surface at few localities, and these are back from the river. The divide west of Salt creek and the Little Stranger is one continuous string of boulders from north to south, overlaid on the higher ridges with the yellow clay. They form rough piles in the timbered slopes to the Big Stranger, and some are over a ton in weight.

The bluffs of the Missouri, as has been remarked, are largely covered with timber, and the appearance of much of the four counties is similar. But it is found that a great proportion of the timber, especially at the higher elevations, is young, the growth that has sprung up since the prairie fires have been kept down. In this is an example of the influence of man in determining topographical forms.

All along the Missouri front, from Wyandotte to Doniphan, landslides have been numerous. In places it seems that nothing but loose earth and vegetation had been moved, but in others, e. g., southeast of Connors station, great masses of rock have slid and turned on their edges, and trees have grown on their flanks. Near Kickapoo and elsewhere this is a constant menace to the safety of the railway roadbed, and therefore a constant expense. The cause of this will appear further on. Landslides have occurred on the inland creeks, but much more rarely than on the Missouri. The drainage system of these counties may be largely inferred from what has been said of the contour of the land, and will be verified by looking at the map. The northern Wolf creek in Doniphan county and the north-south trough of the Stranger cut off the narrow region to the east of them from the general Kansas and Nebraska drainage, and so leave it a region of very short streams, mostly with deep valleys, which in many instances converge and pass through the Missouri bluffs by the narrow openings before referred to, and leaving the bluffs in the form of long ridges with narrow tops, parallel to the river. This is also true, though not so marked, in the subsidiary drainage to the Kaw river, Turkey creek, Muncie creek, Wolf creek, Wild Horse creek and others doing their share in varying the upland and making narrow ridges of the river bluffs.

Proportionally there is more bottom land on the Kaw front than on the Missouri front of these counties; but, owing to the sandy nature of the alluvia, the assumed malarial influences of bottom lands are minimized, while their proverbial fertility is not diminished. The increased elevation of the bottoms for the Missouri valley has been given. For the Kaw valley it will be seen in these figures, which show the railway elevations in westward order: Armstrong, 757; Edwardsville, 785; Lenape, 783; Linwood, 791; Fall Leaf, 811.

The gradual rise of the Stranger valley northward will be seen by comparing the elevation of Linwood, near the mouth, with that of Easton, near the Atchison county line, which is 904 feet; but east and west of which the thousand foot contour is reached in a short distance. The railway elevations for Kansas City, Kan. (760 feet), Leavenworth (770 feet), and Atchison (795 feet), may be noted, but it should be remembered that within a mile or so from the depots these cities run up close to the thousand foot contour, and at a little distance beyond the level is that of the sandstone plateau or the higher limestone table-land. White Cloud is 848 feet above sea level; Troy, 1,095.

With this general topographical introduction we proceed to the consideration of the geology, taking, first, the details from and near the city of Leavenworth, where they have been more completely studied. With it the geology of the other counties may be compared, and some probable inferences made.

LEAVENWORTH COUNTY.

GEOLOGY.

The bed-rock of this county is everywhere of the geologic period we know as the coal measures. This bed-rock is not always hard rock. It is sometimes a soft clay shale (commonly called soapstone) or it is a sandy shale that splits into fine laminae and breaks into square or oblong blocks, as seen in the cut where the Kansas Central and Santa Fe railways cross the ridge in the west part of the Fort Leavenworth military reservation. Sometimes there is a hard black shale that will burn, which in places is salable as coal, e. g., near Kickapoo. Again the bed-rock is a compact though nowhere a very hard sandstone, in which wells find water and near the outcrop of which there are some springs. And lastly, the bed-rock is limestone, sometimes in regular jointed beds of good building stone, but often in irregular layers forming massive beds 12 to 20 feet thick.

THE COAL MEASURES.

The bed-rock described above, if its covering of yellow marl and the alluvia, which we will describe later, were removed, would present a very uneven surface. Probably its hills and valleys would have as great differences of elevation as there are now, and many slopes would be more precipitous. But in that case it would be much easier to see than it is now that the various rock formations lie in a regular order one upon another, and the same ledge of rock often persists with little change of character or thickness for many miles. But though erosion of the valleys in pre-glacial times had cut out vast bodies of the rock material, yet opposite sides of the same valley would show the same layer of rock nearly at the same level. An example of this is seen in the fact that the same limestone that is being quarried on the reservation west of Fort Leavenworth was excavated at Pilot Knob for the reservoir, though in most of the country between it has been eroded out, and materials that were once below it are now at the surface of the lower levels.

Again deep down in the ground the same seam of coal is being worked at North Leavenworth and Lansing, and the same bed of hard shale is above it and bastard limestone below it, with intervening fire-clay. At that depth the strata are persistent for long distances. Great gashes have been cut in them by the wearing of the streams near the surface.

The coal measures at Leavenworth may be said to be about 1,500 feet thick, measured from the top of Pilot Knob to the last black shale, 450 feet below the coal seam now being worked. They are coal measures; that is, they contain coal, but only a very small fraction of this thickness is coal. Six, and in some places seven, thinner seams are passed through before the Leavenworth vein is reached. But one vein of 22 inches thick, at a depth of 700 feet, constitutes this a coal region, without reckoning the workable veins below.

In 1881, Mr. Oscar Lamm, manager of the shaft at the State Penitentiary, published the record of the strata passed through. It is as follows:

Strata Passed Through.	Thickness of strata.		Depth.		Strata Passed Through.	Thickness of strata.		Depth.	
	Ft.	In.	Ft.	In.		Ft.	In.	Ft.	In.
1. Surface clay, bowlders, etc	35	5	35	5	43. Shale, black	1	0	532	0
2. Limestone, gray	12	0	47	5	44. Limestone, gray	3	2	535	2
3. Shale, black	3	11	51	4	45. Shale, black, etc	7	5	542	7
4. Limestone, blue	2	5	53	9	46. Limestone, light gray	3	5	546	0
5. Soapstone, light drab	23	6	77	3	47. Shale, black		6	546	6
6. Limestone, gray-dark	15	8	92	11	48. Limestone, light gray	2	0	548	6
7. Shale, green-gray, etc	23	0	115	11	49. Sandstone, brown-gray,	8	3	556	9
8. Limestone, brown, etc	6	8	122	7	50. Shale, black	12	0	568	9
9. Limestone, gray, etc	7	10	130	5	51. Limestone, brown	3	3	572	0
10. Soapstone, light drab	37	0	167	5	52. Shale, black	2	6	574	6
11. Limestone, brown, etc	17	10	185	3	53. COAL		8	575	2
12. Shale, black, etc	11	8	196	11	54. Fire-clay		6	575	8
13. Limestone, gray-dark	4	10	201	9	55. Sandstone, gray	4	0	579	8
14. Shale, gray-black	3	2	204	11	56. Shale, drab	2	2	581	10
15. Limestone, brown	1	1	206	0	57. Shale, bituminous	1	8	583	6
16. Shale, gray-purple	8	0	214	0	58. Shale, buff	1	9	585	3
17. Limestone, gray	6	5	220	5	59. Limestone, light gray	4	0	589	3
18. Shale, green	1	6	221	11	60. Shale, drab-purple	9	6	598	9
19. Limestone, gray	2	5	224	4	61. Limestone, light gray	2	2	600	11
20. Shale, gray, etc	15	6	239	10	62. Shale, black	4	9	605	8
21. Limestone, drab	10	2	250	0	63. COAL, black		7	606	3
22. Shale, gray, etc	18	4	268	4	64. Fire-clay, drab	5	1	611	4
23. Limestone, gray	2	6	270	10	65. Limestone, light gray	3	3	614	7
24. Shale, gray, etc	4	3	275	1	66. Shale, drab	2	3	616	10
25. Limestone, dark gray	1	11	277	0	67. Limestone, light gray	1	10	618	8
26. Shale, black, etc	5	10	282	10	68. Shale, drab		4	619	0
27. Limestone, light gray	1	7	284	5	69. Limestone, light gray	2	7	621	7
28. Shale, gray, etc	1	6	285	11	70. Shale, black	2	4	623	11
29. Limestone, gray, etc	21	0	306	11	71. Fire-clay, dark	3	7	627	6
30. Limestone, black, etc	4	0	310	11	72. Shale, light, sandy	24	0	651	6
31. Shale, black, etc	10	1	321	0	73. Shale, dark drab	8	0	659	6
32. Limestone, gray	18	8	339	8	74. Limestone, dark gray		6	660	0
33. Shale and limestone, drab, etc.	9	0	348	8	75. Shale, drab, etc	10	1	670	1
34. Limestone, light gray, etc	12	3	360	11	76. COAL		10	670	11
35. Shale, gray, etc	142	8	503	7	77. Fire-clay, drab		2	671	1
36. Limestone, brown		6	504	1	78. Sandstone, black	6	0	677	1
37. Shale, drab	7	10	511	11	79. Slate, drab, etc	7	1	684	2
38. COAL, black		2	512	1	80. COAL		2	684	4
39. Shale, drab	9	2	521	3	81. Fire-clay and shale	1	4	685	8
40. Limestone, light brown	5	0	526	3	82. Shale, dark	3	0	688	8
41. Shale, black, etc	3	9	530	0	83. Slate, drab and black	23	4	712	0
42. Limestone, gray	1	0	531	0	84. COAL	1	9	713	9

Of the 713 feet passed through, Mr. Lamm gives this summary:

Surface clay	35 feet	5 inches.
Limestone strata	191 feet	6 inches.
Sand rock	18 feet	6 inches.
Shale, soapstone, slate	452 feet	6 inches.
Fire-clay	11 feet	10 inches.
Coal (seven seams)	4 feet	3 inches.
Total	713 feet	9 inches.

The last 21 inches of this is the workable vein at the Lansing shaft. It is a little thicker further away from the shaft. Of the other coal seams the thickest is 10 inches.

The record of the drill hole made at Leavenworth in 1887 shows that there are below the Leavenworth seam 453 feet of coal measures, thus:

Shales, various	281 feet.
Sandstones	168 feet.
Coal (two seams)	4 feet.
Total	453 feet.

The Leavenworth Coal Company have bored beneath their vein to a total depth of 1,170 feet, with the following result:

9.0 feet of coal in 12 seams.
191.8 feet of shale, slate and fire-clay, 29 beds.
240.1 feet of sandstone in 23 beds.
18.8 feet of limestone in 6 strata.

They have since sunk their second shaft several hundred feet distant from the drill hole to a depth of 999 feet, which on the whole verifies the drill record, but varied in a remarkable way in two or three instances, showing in two cases 19 inches and 17 inches of coal respectively where the drill showed limestone, and in another place gives coal 13 inches for three thinner seams and shale.

These summaries show that in the lowest part of the coal measures the coal veins are thickest and that sandstones predominate over limestones, and shales still form the largest part of the thickness. This is precisely the condition of things shown in southeast Kansas—Bourbon, Crawford and Cherokee counties—where the lowest beds of the coal measures are at or near the surface.

They also illustrate variations at short distances. The Leavenworth Coal Company's boring shows no coal at 20 to 40 feet below the Leavenworth vein, but their second shaft shows it at 32 feet below, with a thickness of nine inches. The city boring shows it 24 inches at 25 feet below the main seam. The sump at the Home mine shows it 18 inches at 25 feet below, and at the Brighton sump it is reported 16 inches at 30 feet. The city boring gives 24 inches of coal at a depth of 270 feet below the main seam, while the Leavenworth company's shaft shows 26 inches at 290 feet below, with 10 inches more 4½ feet above, the intervening bed being sandstone, while above this is a black bituminous slate for several feet.

Here we have correspondences and variations. From this it would seem that the next coal below the Leavenworth vein has been proven at four of the mines and may be relied on at an average of not less than 18 inches from Brighton to Leavenworth, and that a paying vein has been proved at 270 to 290 feet below the main vein at two places. The main vein has often been called the 21 inch vein, chiefly owing to Mr. Lamm's statement that at the penitentiary shaft it had that thickness. But in that mine away from the shaft, also in the three mines to the north, it is thicker. The average of 15 measurements in all the five mines gives 22 and five-twelfths inches for the thickness in the whole worked field, with enough variation to suggest slight thinning off to the south and west.

Returning to the consideration of the rocks near the surface we get this section as a succession of strata at Ryan's quarry, south of the sugar factory:

7.	Yellow marl slope.	
6.	Weathered limestone	5 feet.
5.	Yellowish and greenish shale ...	3 feet.
4.	Irregularly bedded limestone ...	14½ feet.
3.	Black laminated shale	5 feet 6 inches.
2.	Dimension rock	2 feet.
1.	Gray shale below.	

This succession is very persistent on the Missouri river. It is seen down near the Soldiers' Home, and shows at the Home mine, and partly at Fort Leavenworth. Owing to its surface sometimes being eroded off, No. 4 has been found thinner, and by some persons it is known as "the 13 foot."

The dimension rock, the black shale, and the 13 foot, rough limestone, are companions that give a key to the geology of this part of the county. At Fort Leavenworth the dimension rock is out of sight under water, and the black shales in the water, and the 13 foot is within two feet of the recent stage of low water. But there are variations. In most places the black shale does not exceed four feet, and in some places the yellow shale (No. 5) is reduced to two feet, and even to a mere shale parting of less than a foot. No. 6 is pierced with holes worn by the weather and water when the river was at a permanently higher stage. With shale partings between its irregular layers it runs up to 15 feet or more, 4, 5 and 6 having an aggregate thickness, where fully developed, of over 30 feet. This thickness is shown towards Fort Leavenworth.

Above this section we have shown at much higher levels in the different localities another series, which culminates at the top of Pilot Knob.

This series near the top is singularly like the section just given. We have it shown at Pilot Knob and in the government quarries west of the fort, thus:

Rough limestone, 10 feet. (14 feet at Pilot Knob.)
Laminated buff shale, 2.6 feet.
Laminated black shale, 3 feet.
Dimension rock, 2 feet. (1 foot 10.)
Shale.

Here are dimension rock, black shale and rough limestone just as at the river bank. It is a repetition. There are 250 feet between the two similar sections, and that space is filled mostly with sandstone and shale, with a few thin layers of limestone and a heavy, limy, yellow sandstone, of which the governor's house at the Home is built. In this horizon of over 200 feet sandstones prevail as at Brighton over 30 feet thick, and elsewhere shales. But the shales are often laminated and have flaggy and other sandstones among them, as may be seen in the railway cut on the reservation. They are also black and carbonaceous, and in places develop into coal, as on Salt creek and South Stranger.

The complete section would be about thus:

10.	Rough limestone (Pilot Knob)	10 feet.
9.	Black and lighter shale	6 feet.
8.	Dimension rock (upper)	2 feet.

7.	Shales and sandstones with some limestone ledges	250 feet.
6.	Rough limestone ledges and some intercalated shales	6 or 8 feet.
5.	Yellowish, green shale	3 feet.
4.	Rough limestone	14 feet.
3.	Black shale	5 feet.
2.	The dimension rock	2 feet.
1.	Shales.	

No. 7 may be divided about as follows, beginning at the bottom, but the thicknesses vary greatly within the limits from Lansing to the fort:

a.	Brick shale, and in places two beds of limestone	40 feet.
b.	Sandstone and sandy shale, and the yellow limestone	65 feet.
c.	Brick shale	20 feet.
d.	Sandstone	20 feet.
e.	Shales and sandstone with layer of limestone near the top, and thinner ones lower	100 feet.

At the Soldiers' Home immediately above the No. 6 lies the shale out of which the vitrified bricks are made. Its lowest parts are blackish (carbonaceous). The middle is sandy laminated, the upper part is more marly clay shale; that is, the brick shale is the lowest part of No. 7. It shows, lying in the same position, on No. 6, north of the Riverside mine, and again north of the Home mine, and again as far north as Kickapoo. Further south on Island creek, sandstone rests directly on limestone which is perhaps No. 6. The brick shale in other places will be referred to further on. Shale of a very similar texture is seen in the bottom of the cut on the reserve, and probably will be found at various levels from 40 to 100 feet above the lower dimension rock, or at similar distances below the Pilot Knob rough limestone.

I have said that the rough limestone of Ryan's quarry appears on the bank of the river near Fort Leavenworth, but there is a remarkable change between the two places. South of the sugar factory this limestone is many feet above the railway track, and so shows itself from the Home mine to Spruce and Olive streets. But from there northward it is no more seen on the railway track till we reach the mouth of Two Mile creek. Under the waterworks bank and further north there crop out shale with ledges of flaggy sandstone. These ledges have a decided dip toward the south. Going down to the water's edge at one spot there is sufficient freedom from debris to see the outcrop of No. 4. The top of it is just 14 feet above the water at the day I measured it, which was just at the time the ice was breaking up. This would carry its base down into the water. North of the bridge its base at the same time was several feet out of the water, and the black shale above water level, so that it comes up more rapidly than the slope of the water surface. There must be a great depression of strata northwest from Olive street to the north limit of the city, which is changed about there to a northerly rise. The absence of hard rock in the bluffs north of the depot is accounted for by this, for the sandstone would more readily wear away, and loess has filled in the lower levels.

It is remarkable that in the Leavenworth Coal Company's mine there is a decided change of dip some distance northeast of the shaft. It dips northerly by east at an angle of 13 degrees for over 400 feet, and then the continuity of the coal seam is interrupted by a "trouble"—not like a trap dike common in some coal regions, which is igneous rock protruded from below, but this trouble is a broken mass of stratified rocks apparently dropped in from above. After the trouble is passed through the coal seam is continuous beyond, but rises to its former level. It was probably some seismic action that opened a gap and let the upper strata fall in, but the gap was closed before any great fracture had occurred at the surface. Only a sag took place there, represented by what we now notice only as a comparatively slight change of dip. And yet there may be more change, even fracture, near the surface than we can discover, as the heavy cap of loess hides the bed-rock all through the northern part of the city.

There also appears to be a slight difference in the level of some strata on both sides of Five Mile creek, but this I could only be sure of by actual leveling. It is, however, probable that all watercourses more or less correspond to the breaks or changes in the direction of the dip of strata.

At the south side of Three Mile between Second and Third streets, and also at the rock expose, south of the railway yard, it is seen that the rock dips to the west. This westerly dip, combined with the northerly, gives a general west by north dip which, with some exceptions, carries down the various strata out of sight as we go away from the river, and others come in on the top. This is true probably for the whole thickness of the coal measures. The westerly dip is well illustrated by the position of the coal at Brighton, as compared with that at Lansing. The distance between the two shafts is 2¼ miles, almost due west. The coal at Lansing is 714 feet deep; at Brighton it is 811 feet. The difference of level of the tops of the two shafts, as determined by the railway survey, is 67 feet 9 inches, which leaves a depth of 29¼ feet to be accounted for by the dip between the two mines. This gives a westerly dip of 13 feet per mile for the main coal. As the dimension rock is 29½ feet lower at Brighton than at Lansing, this practically gives the same dip at the surface.

The northerly dip of the district is seen in the difference above sea level of the dimension rock and the Leavenworth coal vein at the penitentiary and the Leavenworth Coal Company's shaft:

	Elevation Penitentiary shaft.	Elevation Leavenworth Coal Co.	Difference.
Top of shaft	828.0 feet.	810.0 feet.	18.0 feet.
Dimension rock ...	774.9 feet.	776.9 feet.	
Vein coal	116.6 feet.	103.5 feet.	13.1 feet.

This gives a dip at the dimension rock which is near the surface of only a foot and a half and the vein coal of two feet four inches per mile. The two mines are five and one-half miles apart, and the more northerly one is nearly a mile further west than the other. There are local dips in the two mines which lie between which exceed this amount, but they recover themselves in short distances.

That this northerly dip is changed into a northerly rise north of the waterworks has already been noted. The dip westerly is, however, more continuous, though there are local easterly dips in several of the mines.

The westerly dip carries all strata of the eastern part of the county downwards considerably in a few miles, so that in the valley of Little Stranger and Salt creek none of the strata of our lower dimension rock series are visible there, and the sandstones and shales that lie high up on the west of Pilot Knob ridge are found in the bottom of the valley. Some of the carbonaceous shales of eastern uplands there become more like coal, and at the southern part of the divide between Big and Little Stranger there is one seam of good coal.

THE DRIFT.

Under date of August 27, 1868, Wilder's Annals of Kansas has this passage: "Prof. Louis Agassiz, Roscoe Conkling, Ward Hunt, and other eastern men, visit Leavenworth. Agassiz said he had never seen such good soil as he had seen in Kansas and Missouri." This is part of a much longer passage, which is an abbreviation of an article a column and a half long in the Leavenworth "Conservative" of the same date. Professor Agassiz was the apostle of the drift. It was he who by study of the glaciers in his native Switzerland rose to the scientific explanation of the drift deposits of northern Europe and northeastern America. He converted to his theory every distinguished geologist of his day, including Sir Charles Lyell. In addition to recording the fact of the visit of Agassiz to Leavenworth, D. W. Wilder has told the writer an interesting incident of that visit which I think I am violating no confidence to repeat. Agassiz said to Wilder, "Have you any boulders here?" "Our Web", though not a geologist, said he thought there were, remembering a stone somewhere about the city that he guessed was what the scientist wanted, and they went out from the assembly of railway magnates to look at a rock. Agassiz was overjoyed. He was delighted, and said he had found here, 5,000 miles from his home, the confirmation of the theory he had worked out in Switzerland. If we could only find that particular stone we would set it up in front of the Leavenworth high school and imbed in it a tablet of enduring brass to record its interview with the arch-interpreter of boulders.

That boulder was one of many that may be seen within the civic boundaries of Leavenworth—one of multitudes that are scattered over the county, that in some places are like great streams of stones on the prairie, that on some high tops are so close together as to suggest artificial pavement. These red, gray and green boulders with associated gravels and some forms of clay and some markings of the bed rock constitute the phenomena which we include in the term drift. These boulders have come from far. Though much older here than Regis, Loisel, or Coronado, they are not native Kansans. They were brought here by a force tremendously in excess of their own inertness. They were brought by the ice that overspread all the continent to the northeast, which ground its way over the granites and greenstones and hard limestones of British America and Minnesota, tearing huge masses from their beds and doing the same with the hard red quartzites of Minnesota and Dakota, and bearing the accumulation, with scarcely more than the sharpest edges worn off, to be dropped out in Kansas and Iowa when the ice melted under the returning geniality of climate.

The boulders are of all sizes, from that of a nut to a mass of several tons. In Leavenworth county there are comparatively few along the Missouri river front. They are found in great numbers along the sides and top of Pilot Knob ridge and the valleys of Seven and Nine Mile creeks, and still more numerous on the other side of the ridge toward Little Stranger and Salt creek. On the watershed between the two Strangers they are in great force. The ice containg the boulders probably ground down the surface of that slope to the south, and in time of melting rested there while its stony burden was strung along the surface. Gravels as separate deposits with few boulders are scarce, but they may be seen near Lansing and northwest of Tonganoxie and in some of the valleys in the north part of the county. West of Salt creek, passing the Eight Mile House, going west, there is a fine succession of boulder deposits. They are of all sizes up to more than a ton, and occur in the road cuts below the tops of the hills on every successive ridge for four miles. They are seen on every road south to beyond Boling, and constitute a fine example of a glacial moraine. The mineral well on Little Stranger comes from below a mass of this morainic material which has been made into a heavy conglomerate by ocherous cement.

In places there is a tough, sticky, dark colored clay, with pebbles and small boulders resting on bed rock, which is the product of the ice action in grinding up the shales, sandstones and limestones over which it passed. It is called hardpan or boulder clay. I have seen but little of this in Kansas, and usually the plainest drift products are the accumulations of boulders and pebbly gravels.

In the absence of hardpan, these rest on the bed rock of the district. For long ages the Missouri river and its tributaries had been washing the surface of the coal measures and had carried away in this region the last vestige of any newer formations that might have been above them, and the valleys nearly on the present lines were cut out. Then came the ice planing down the surfaces, widening the valleys and narrowing the ridges. All river courses were dammed, and the great streams of the Missouri, Platte and Kaw were sent in new channels around the ice front or scattered in great lakes, and in these lakes and streams ice floated from the edge of the glacier, both at its greatest southern extent and when it was melting away and retreating northward. These icebergs carried boulders and dropped them far away in the deposits of sand and clay that settled from the cold waters.

In Dakota, churches are built of some of these boulders. Most of them here are the red, hard quartzites, which will take a beautiful polish. The time will come when these troubles of the farmer will find a utility and a place in ornamental building.

In the region south of the limit of the ice the rivers and lakes were laying down a yellowish deposit, very like the present mud of the Missouri river, and as the ice melted this followed up the retreating glacier, and the yellow marl lies over the deposits of boulders, which are exposed where modern erosion has thinned out or entirely removed the marl, as in some of the localities mentioned.

Both boulders and marl are found on the highest land in this region, testifying to the mass of ice and the flow of water, whose action was probably aided by some changes of level the extent of which we cannot at present even guess in this region. Of the marl we shall now more particularly speak.

THE YELLOW MARL—LOESS.

Nearly everywhere in Leavenworth county this bed-rock shale, sand or limestone is covered with a coating of yellow marl before referred to. It is is shown in the bluffs of the Missouri river 30 feet high. Sometimes it is only three to five feet thick, and caps bluffs of limestone or shale. It is in places nearly 100 feet thick, and is so prevalent that bed rock is only seen in the precipitous bluffs of the river, the higher ridges and ravines. The name loess is from the German (loss), as a similar formation so named is found in Rhineland. It is sometimes called the bluff formation because it is so conspicuous in the Missouri river bluffs from below Kansas City to Yankton.

The name yellow marl describes its color and composition. It is a limy, sandy clay with streaks of sand and gravel, and its color is a little brighter than the recent deposits of Missouri river mud, which, in its mechanical structure and chemical composition, it greatly resembles.

The yellow marl was deposited from the waters of streams or lakes of fresh water which covered the country in front of the ice of the glacial period and which followed the ice as the melting at the southern edge caused its retreat to the north. It covered the whole of Leavenworth county. It has been eroded from part, but it is the subsoil of the high, rolling prairie and is under the smooth bottom land of Stranger creek.

As in Kansas the ice came down as far as the south side of the Kaw river and as far west as the Blue, all the valleys of northeastern Kansas, as well as eastern Nebraska and eastern Dakota, were filled, and the great streams of the Missouri, Platte and Kaw were scattered on the western plains, and the loess was deposited at levels up to 1,500 feet. But on the retreat of the ice the drainage that had been stopped began again, and the soft yellow mud that had smoothed over the rugged ravines of the pre-glacial time began to be washed out, and the modern drainage channels were probably established before the prairie grass obtained its hold or the trees began to grow in the ravines.

Men lived somewhere near while the loess lakes were in existence. We find their weapons in the loess, and very likely from the first drying up of the land they hindered forest growth by fires.

The loess in its deposit to a very great extent smoothed over a very rugged country, in some cases adding height to bluffs that would be conspicuous without its aid. The economic value of the loess will appear further on.

Every valley has in its draws and slopes land that has been made by the material washed by rain and stream from the higher levels. This is called alluvium. The various kinds of alluvia are gravels, sand, clays, gumbo or modifications of these and are sufficiently well known not to need particular description. They are the latest geological product, belonging entirely to the present stage of surface changes.

ECONOMIC GEOLOGY.

It will be recognized that many of the facts previously stated have a commercial value. I shall now more succinctly put together the economic results of this investigation.

COAL.

In the early history of Leavenworth county coal was mined by drifts from several veins of coal near the surface at or near the same geological horizon, at Kickapoo, on Little Stranger creek below Boling, and on Big Stranger near Tonganoxie. The Little Stranger mines were the most numerous and apparently worked most systematically, and they supplied coal in considerable quantities until the opening of the Leavenworth deep mine in 1870 shut off their principal market. This seam furnished a large supply to the city and county. Mr. Peet worked it back in the fifties, and Mr. James Orr and Mr. Hyde began later. These persons owned the land, and sometimes mined themselves and sometimes they gave it to others on royalty. As many as 12 drifts were made into the side of the bluff, those furthest south being at the level of the coal, four feet above the creek bed. Further north the creek was diverted and several acres at and below the water level were stripped and the coal taken out. Higher up some drifts were made into the bluff sloping down to the coal and the water was dammed out. Mr. Orr sunk a shaft 14 feet and worked chambers to the northwest to a distance of over

200 feet. It would appear from such records as I have seen that in 1867 and 1868 not less than 50,000 bushels were taken out each year, and the aggregate was probably not less than 250,000 bushels. The coal as seen now at the outcrop is from 18 inches to two feet thick. The upper third is decidedly inferior quality, but the lower part is as good coal as is obtained in the region. It was used in early days by the blacksmiths and by the gas company as well as by mills and foundries. It is easily accessible by a railway switch a mile long and can be cheaply mined. It cannot afford to be carried on country roads in competition with Leavenworth coal with railway rates. The area underlain by this coal is several hundred acres and may be more.

There is still a body of coal in that district which, notwithstanding some disadvantages, can be cheaply mined. Its extent cannot well be less than 500 acres, and it is possible it may be three or four times as great. Worked on the long-wall system an acre of coal one foot thick would give 44,000 bushels, and it is within bounds to say that the Little Stranger coal would average 16 inches of high quality, though it has the disadvantage of being associated with six or eight inches of less value that would have to be mined with it. It is covered with shales and clay to a depth of 30 to 50 or 60 feet. The thicker coverings include a bed of limestone four feet thick.

There is a coal on Salt creek and on Big Stranger near Tonganoxie at somewhere near this horizon, but the weather prevented my determination of its exact relations or its thickness.

The time will come when these upper seams at Big Stranger, Little Stranger, Salt creek and Kickapoo will again become important parts of the resources of the county, though they may not rank in value with the output of the coal from the Leavenworth deep vein.

These coal seams are accompanied by shales some of which will certainly make vitrified brick, and it may be that exposition of the problem of their use lies in this association, and we may have successful brick, tile and pottery yards in the central section of the county where the clay and the coal will be on the same land.

The story of the development of the deep coal at Leavenworth has been often told. I only refer to it to express my own appreciation of the perseverance and spirit of Major Hawn in not giving up when the depth was greater than he had at first anticipated. To him the city of Leavenworth is indebted for the principal factor of its prosperity.

The seam of coal which I call the Leavenworth main coal is now being mined in five places. From the Leavenworth company's shaft in the north to the penitentiary shaft the distance on a north and south line is 5½ miles, the latter being about a half mile to the east. Add to this the distance of the southern face in the Lansing mine and the northern face in the Leavenworth mine from their respective shafts and we have a north and south extension of proved coal of fully seven miles. The distance of the penitentiary and Brighton mines in the same way gives us a proved existence of three miles east and west. We have then an area of 21 square miles in which the coal is known, having been proved by the successive sinking and successful working of the

Leavenworth Coal Company's shaft	1870
Penitentiary shaft	1881
Riverside mine	1886
The Home mine	1889
The Brighton mine	1889

I have carefully weighed 10 specimens—two from each mine in the district—and find the average specific gravity of Leavenworth coal to be 1.283. This gives 80 pounds 3 ounces as the weight of a cubic foot of Leavenworth coal. That is, a cubic foot is almost identical with a bushel.

This may be compared with some English and Pennsylvania coal, whose specific gravities are as follows:

Newcastle coal (Hartley mine)	1.29
Wigan "four feet"	1.20
Pennsylvania	1.40
Leavenworth	1.283

If we estimate that the length of the coal vein be extended to 10 miles and the breadth of it as now known be increased one mile, which is an extremely low estimate, we should have an area of 40 square miles, which, with the average thickness before given of 22 5-12 inches, would give a total of 2,083,136,000 bushels. This, at the rate of output for 1891 (7,479,406 bushels) would last 280 years, or if the rate of output were doubled would hold out 140 years, which might be reckoned from 1885.

I have previously stated that a lower coal vein has been proved at four places within the district. If its average thickness were taken at 18 inches over the same area the present output might be doubled and the coal would still last over 200 years. It is probably safe to predict that before that time other fuels will be largely used. Of these we shall speak further on.

In 1888 a boring was made at Tonganoxie to a depth of 852 feet. The last 22 inches is given in the drill record as coal of the best quality, and it is claimed that it is Leavenworth coal. The upper part is very different in its succession of strata from the Brighton mine, which is the nearest of the Leavenworth mines, but the lower part shows some similarity in the occurrence of sandstones, black shales, thin coal and fire clay; so that there is no good reason to doubt that coal is there, and if not actually a continuation of the Leavenworth main coal it is not far from the same horizon. If it were the same seam the area of the coal field would have to be taken at double or treble the estimated area given above. A consideration of the south by west trend of the elongation of the other veins of coal in Kansas is in favor of expecting continuity of the Leavenworth vein in the direction of Tonganoxie.

It is a well known fact that coal seams run out in the course of a few miles in given directions, and are replaced by shales or other deposits. The converse of this is also true, that in the opposite direction the shale sometimes becomes coal. If then a seam of coal should be found very thin at some spot and it were known not to exist at all in a given direction, it might possibly be found a vein of workable thickness and high quality in the opposite direction. If, then, in the future it should be desirable to make a test with a diamond drill in the valley of Little Stranger, besides the coal near the surface, already described, the 8-inch, 7- and 10-inch veins of the penitentiary shaft (at 575, 606 and 670 feet, respectively) might possibly be found each about 100 feet deeper, and one or more of them might give a workable coal, before the horizon of the main vein was reached.

Of the heat-producing power of the coals of Kansas, Professor Blake, of the state university, has made a full comparative report, in which he says: "The coals depreciate in their steam-producing powers from the southeastern part of the state toward the north and west," but Leavenworth coal is so far an exception to this rule that in the tables it is bracketed with the Cherokee upper vein and comes before Osage and Franklin county coals. The best Indiana block coal is shown for comparison.

Pounds of water evaporated per pound of coal used:

Place.	10 per cent. correction.	30 per cent. correction.
Leavenworth	12.54	14.80
Indiana (Clay county)	14.53	17.03

The methods of this determination are carried out in apparatus that assures nearly perfect combustion, and Professor Blake remarks that, "about one-half the evaporative powers here given under the 10 per cent. correction will be obtained in practice" in steam boilers.

Prof. E. H. S. Bailey gives an analysis of Leavenworth coal as follows:

Water	2.69
Volatile	39.21
Fixed carbon	47.41
Ash	10.69

And arranging the coals of Kansas as to their value, as shown by analysis in five groups, Professor Bailey places that of Leavenworth in the second group.

The black bituminous shales of the surface and down in the mines will some day be sources of heat and illumination to the larger populations of the future. They will all yield oil and gas by distillation, and when supplies of petroleum, now constantly decreasing in the eastern states, are exhausted these shales will everywhere be a source of wealth to the communities that have them. It will pay better to mine them then than to mine coal to-day.

MINERAL PAINTS.

The bed of shale immediately above the 13 feet of limestone has a yellow streak near the bottom that in many places is a good bed of ochre. It is seen at Ryan's quarry and at the soldiers' home. Other parts of the shale beds have similar deposits. There is also purple brown shale at a higher level that shows on Salt creek, Little Stranger and near the Wyandotte county line, that apparently would make a paint of the umber class. The yellow ochre calcines a beautiful brown. These shales all belong to the coal measures.

In a great many places the bottom of the yellow marl is a rich red clay, free from sand, which from the quantity of iron in it will make a good pigment for outdoor painting. It will have to be sought for and may be found where the superincumbent marl is not very thick, and the paint-bed itself may be found sometimes two or three feet thick. Under the circumstances of frost and snow in which this examination has been made it is impossible to get at the thickness of these soft deposits. This rich clay has, however, been seen in the western part of the city and on slopes of Salt creek and Little Stranger.

CLAYS.

Leavenworth county is rich in clays for all kinds of bricks and moulded blocks. The most prominent feature of the region, the loess or yellow marl, is over a large part of its area fit for the best kinds of common bricks. It can be found sufficiently porous for draining-tiles and also of quality suitable for compact pressed bricks. The loess is everywhere. Experiment determines its value. If inferior bricks are made it is usually the fault of the maker, either in selection of his clay, or in its manipulation and baking.

The bricks that are now claiming so much attention are the vitrified bricks for paving.

These paving bricks are made of shale (or shales) of the coal measures. The outcrop that has become best known is at the soldiers' home, where it shows from 20 to 30 feet in thickness. It forms the lowest part (a) of No. 7 in the section on page 236. It is mainly a clay shale called by the workmen soapstone, but it changes into luminated sandy shales in parts of its thickness. Sometimes the best results are obtained by selecting a particular part of the thickness of the bed. At others the proper proportions of sand in the clay are obtained by mixing all the parts of the entire stratum. The iron that seems to be a necessary part of a clay for vitrified bricks is found in some parts of the shales as bands of limonite nodules or concretions, which are ground up with the rest of the material, but elsewhere there are no concretions, yet sufficient iron is distributed in streaks and ocherous stains through the substance of the shale.

It is a feature of these brick shales that they contract considerably in burning, to the extent sometimes of one-eighth of the linear dimensions of the bricks, which in the cubic contents is a diminution of bulk in the ratio of 512 to 343. This must be allowed for in the making of the bricks, and the heat of the drying shed and the kiln must be so regulated that the contraction shall be regular. The proper time for tempering the material before use is also important, and the use of winter frosts for this purpose should have attention. With care on all these points and attention to results of previous experience the brick shales of Leavenworth will produce as good results as anywhere. It seems that one of the solutions of the problem of the pavement of the city streets is found in the use of vitrified bricks.

The material for making them is abundant. The geologic position which we will call No. 7a, is easily found, and where not eroded it is of the brick shale quality very extensively. It may be seen cropping in the

1. River bluff near the railway-yard limits, northwest of Riverside mine.
2. River bluff under the South Esplanade, north of Home mine.
3. River bluff near Fort Leavenworth.
4. River bluff at Kickapoo.
5. Santa Fe cutting south of crossing of Fourth street, near soldiers' home.
6. Santa Fe cut northwest of Fourth street crossing.
7. Santa Fe and Southwestern cut near linseed-oil mills.
8. On street cut in the city on Shawnee street.
9. On bank of Three Mile creek on West Cherokee street.

There are places where the brick shale shows only a little, as under the loess at Geiger's quarry, where going back into the hill would probably show it of considerable thickness, and above Ryan's quarry, where it does not show at all in the outcrop. Similar beds are found in the higher parts of No. 7 (c and e) which show at the railway cut on the military reservation, on the flanks of Pilot Knob ridge, in the bluffs of Little Stranger and on Seven and Nine Mile creeks. The shales immediately above the coal on Little Stranger have great similarity to the proved qualities of brick shale.

The experience already attained in the making of paving brick, flooring tiles, curb blocks and Roman bricks from these brick shales warrants the expectation of still greater successes, and that terra cotta of the best quality may be made for use in ornamental architecture. At one of the brick yards an improvement of the common bricks has been made by an admixture of loess clay with the brick shale, and this admixture has also been made by nature where the loess and the brick shales come together, a greenish clay with red streaks being the result.

It may be stated that many blocks on Broadway have been curbed with the moulded blocks, and they have worn well.

There is another source of material for bricks. It is the dump piles of shale at the various coal mines.

The brick works at the penitentiary use this material exclusively. The hard "slate" which forms the roof of the coal is brought to the surface when it has been cut out to form the main entries of the mine. There are streaks of limestone or limy shale in this roof slate that do not improve the quality of the bricks, but if these are thrown out the material makes a fair vitrified brick. It is extensively used for sewers and paving, and will have still further development.

CEMENT.

I have not recognized here any gypsiferous deposits that would be suitable for plasters, but some of the shales are probably sufficiently calcareous to have some utility in that direction. The bed of limestone elsewhere mentioned as being in the shales lying over the coal on Little Stranger creek has considerable resemblance to the Fort Scott limestone, which is the only Kansas bed which so far has produced an hydraulic cement which has withstood competition and has obtained an established place on the market. It is probable that some shale beds and some other limestones may yet be found with hydraulic properties that may take a place among the regular products of the district. But the value of these can only be determined by actual experiment.

MINERAL SPRINGS.

There are no springs in this region that are noted by their force and large volume of water. But the numerous creeks of the district are fed by constant seepage from the sandstones, sandy shales and occasional gravels of the region, and wells varying in depth from 20 to nearly 100 feet have plenty of water in all parts of the county.

There are, however, in the region of the outcrop of the various parts of No. 7 of our section springs with a perennial flow of water. And several of these have decided mineral qualities. Coming out of sandstones that are charged with iron as carbonate or oxide, or from shales that besides iron have alum and other salts as well as sulphur in pyrites, the waters are charged more or less with these minerals, and some of them have without doubt valuable medicinal properties. I have visited three localities where such springs are found. One is on the Doctor Marshall place, near the Wyandotte county line, on Island creek. The water comes out near the contact of sandstone and limestone. There is certainly some iron in the water, but only a chemical analysis can determine its quality and medicinal value. Its quantity can only be found by having it cleaned out, as much debris has recently fallen into it and obstructed its flow.

Other springs are on the Ramsey farm, less than one mile northwest from the last. One of these is said to taste and smell strongly of sulphur, but it now fills a small pool for cattle that makes it difficult to obtain the water direct from the spring. Much of this has been taken away by the country people at different times.

The third region is on the Little Stranger creek, west of the Brewer farm. The bed-rocks in place here are a soapstone shale at and a little above the creek bed and a yellow sandstone on the shale in several low bluffs, the whole capped by loess on the slopes.

At the spring the yellow sandstone is missing and an immense mass of boulders—some way worn—imbedded in an ochreous cement, rests directly on the shale. The morainic mass is, like the rest of the outcrop, capped with loess. The boulders are of all kinds, the quartzites, greenstones and granites being accompanied by a much larger proportion of local rocks than is usual. There are two local limestones that are larger than any I have elsewhere seen in the drift. Some of the boulders are blocks of shale that have probably not been carried many rods from where they were torn out of their parent beds. Some of the shale here tastes strongly of alum, and all the coatings of the surfaces of the various rocks testify to the presence of iron. It is said that iron pyrite cubes have been dug out of the spring. The whole is at present choked up with recently fallen debris, but the surroundings are such that after a proper analysis of the quality of the water were made known a health resort here might well be made popular, as there is an abundance of shade and breezy heights, more than 300 feet above the Missouri river. The surroundings of the springs previously mentioned are also favorable for making them places of resort.

Chalybeate waters, sheltered valleys, breezy uplands form a conjunction desirable for the resort of those who seek health and those who are desirous of rest.

SOIL.

From what has been said it will be inferred that the loess is the subsoil of much of this county. This is true, and though it is yellow and in many places a heavy clay, yet it is a good soil as soon as broken by the plow. It is not bad for wheat, the vines love it, and all trees flourish in it.

In the Stranger valley the loess lies under several feet of black soil, which probably has been produced through the change of the subsoil by long production of vegetation, but there are black soils in some upland valleys—on Salt creek and both the Strangers—which it seems hard to explain in the usual way. It would, however, take both a chemical and mechanical analysis to prove a different origin. Enough, however, has been observed of them to suggest that possibly they may owe their origin and blackness to the breaking down of the carbonaceous shales of the coal measures. So their color would still be due to vegetation, but of Paleozoic time. It will need, however, much and special work to determine this. Suffice it that the soils of this county, black or gray or yellow, are all fertile, and will repay culture by plenty.

BUILDING STONES.

The rough limestone of the "13-foot" and the similar Pilot Knob stone yield but an inferior building material, though there is one layer of each that is of a better quality. They will all, however, make lime.

The two limestone layers we have called the upper and lower dimension rock, on the other hand are both hard and compact and yield little to the influence of frost in buildings. They can be quarried in blocks of almost any size and of even thickness. The lower dimension (No. 2 of this section) is only accessible in ravines and on the river south of the city. The upper one in ravines to the west, on Salt creek, on the Stranger near Easton, and probably on Little Stranger. In the southern part of the county there is much limestone, and some of the beds cropping on Wolf creek are identical with strata that have been quarried at Kansas City.

The sandstone that crops at Brighton and on Five Mile creek shows solid beds in the cuts on the Topeka & Southwestern railway as well as on Salt creek and near the crossing of the Santa Fe and Wyandotte railways on Wolf creek, and there must be many places where it would serve well for building purposes. There are a few small houses built of it near the head of Little Stranger, and there may be more. It is, however, mostly very friable, and the harder beds must be looked for.

Finally, the resources of Leavenworth county may be summed up thus: Abundance of coal, that will last for several generations; practically inexhaustible quantities of brick shales that will pave a hundred cities, brick clays for all classes of buildings, some building stones, both limestones and sandstones, mineral waters in various parts, and soils of unsurpassed fertility, all of which only await his bidding to be of service in "the amelioration of man's estate."

WYANDOTTE COUNTY.

This county is sub-triangular in form, and two of its sides are bounded by the Missouri and Kaw rivers. Though narrow from north to south, the rise from each river to the central upland is rapid, and the elevation reached is in places over 1,000 feet above sea level. A considerable portion of the northwest forms part of the sandstone horizon previously described.

The geology is not very different from that of Leavenworth county. The bedrock belongs to the coal measures. Thirty years ago Professor Mudge said that the dimension rock, which figures so conspicuously about Leavenworth, was found on the river at Quindaro. It is now impossible actually to trace the continuity of stratum from one place to the other, or to say that it is not continuous, owing to the covering of the lower beds of the river outcrop by the debris of the railway embankment and by landslides. It would take a very close and long-continued observation to determine the continuity or otherwise of the limestone strata through the river front of these counties. It ought to be done, but the present writer has not had the time at his disposal to accomplish it. I will repeat here the section at Leavenworth with which to compare the following rock sections in Wyandotte county:

A.

10.	Rough limestone (Pilot Knob)	10 ft.
9.	Black and lighter shale	6 ft.
8.	Dimension rock (upper)	2 ft.
7.	Shales and sandstones with some limestone ledges	250 ft.
6.	Rough limestone ledges with intercalated shales	6 to 8 ft.
5.	Yellowish green shale	3 ft.
4.	Rough limestone	14 ft.
3.	Black shale	5 ft.
2.	The dimension rock	2 ft.
1.	Shales to the river.	

The lower part of No. 7 contains the brick shale of the soldiers' home.

On the Missouri front, east of Quindaro, we get this section:

B.

g.	Rough limestone with shale partings	20 ft.
f.	Shale (brick)	12 ft.
e.	Limestone, with fossils and intercalations of shale	5 ft.
d.	Shale	5 ft.
c.	Limestone, with layers of chert	10 ft.
b.	Laminated shale (limy)	2 ft.
a.	Dimension rock (?)	3 ft.

In one place the lower layers of (e) are consolidated into one and simulate the dimension rock. Which of these, (a) or (e), did Professor Mudge identify with the Leavenworth rock? Probably the lower, as the series (a), (b), (c), has more resemblance to the Leavenworth series than any other part of the section. The thicknesses of the upper part of this section suggest similarity to the section at Fort Leavenworth. The dimension rock (a) at the ravine half a mile east of Quindaro, where it is best seen, is at the railway level. There is a northerly dip here which carries it out of sight at the old Quindaro ravine. At Connors, a slope yielded little distinct outcrop; but at 75 feet above the railway a quarry is worked in 15 feet of limestone, and 70 feet higher, limestone is again seen 8 or 10 feet thick on top of the ridge. A little west of Pomeroy the following section was obtained:

C.

i. Limestone in several rough layers	10 ft.
h. Slope (shale ?)	20 ft.
g. Limestone	6 or 8 ft.
f. Shale	17 ft.
e. Limestone	10 ft.
d. Shale	16 ft.
c. Limestone	5 ft.
b. Black laminated shale	2 ft.
a. Layer of limestone	1½ ft.

Further west more precipitous bluffs show that the limestones are thicker, upper and lower soft layers having in the section been weathered and hidden in the stopes. (g) Shows fully 15 feet. (a) Is 10 feet above the railway track; but nothing shows below. Nearly all stopes are topped with the yellow clay —the loess. It is almost impossible to trace any bed of rock inland, owing to the great erosion and the covering of loess. At the quarry, where the shale is obtained for the Adamant brick works, and the ravine below, this section was obtained with some approximation to certainty:

D.

Loess.	
Limestone	1½ ft.
Shale, brownish	2 ft.
Blue shale (brick)	15 ft.
Limestone, three or four layers	2½ ft.
Greenish blue shale	4 ft.
Limestone ledge, top just seen.	

In the Kaw valley, the following section is obtained at Armstrong:

E.

h. Rough limestone, about	20 ft.
g. Shale (brick)	10 ft.
f. Limy ledge	1 ft.
e. Shale or shaly rock	3 or 4 ft.
d. Layers of limestone, flinty, 2 or 3 ft., thickening westward to 9 to 11 ft.	
c. Shale, carbonaceous, and clay	2½ ft.
b. Massive limestone	6 ft.
a. Limestone	1 ft.

This is not unlike the Quindaro section, and may be taken as the prevalent arrangement of the bed rocks up to the elevation it reaches all over the city area and some distance west. Something else comes on at higher levels. (d), In the above section, is at the railway level at Martin's dairy; but (e) is above that level a little further west.

A section further west, where the river and railway come close under the bluffs, and the highroad is on a shelf above, is as follows:

F.

Flaggy, ferruginous limestone above, becoming thick and white below, with a thick shale parting near top	18 ft.
Shale	4 ft.
Limestone ledge	1 ft.
Carbonaceous shale	3 ft.
Limestone—the top foot flaggy	13 ft.
Stratum, with some limestone	8 ft.
Stratum and 2 feet of limestone, to railroad track	10 ft.

A little further west there is this outcrop:

G.

Limestone rock, lower half rough	25 ft.
Shale	12 ft.
Ledge	1 ft.
Shale	2½ ft.
Limestone ledge	1½ ft.
Shale	4 ft.
Limestone in layer, with flints, (d) of the Armstrong section	8 ft.
Shale	2 ft.
Limestone, thick bed at railroad level, thin layers below	11 ft.

River is about 10 feet below.

Across the river at Argentine, street excavators in progress at the water-works hill, exposed the section following:

H.

Fusulina limestone	8 ft.
Sandstone and sandy shale	20 ft.
Fusulina limestone	6 ft.
Shale	4 ft.
Limestone, upper half oolite	12 ft.
Soapstone (shale)	7 ft.
Rough limestone	11 ft.
Rough layers, with thick shale partings	5 ft.
Rough limestone	16 ft.
Laminated sand shale, in parts almost sandstone	25 ft.
Limestone	10 ft.
Shale	12 ft.
Limestone	10 ft.
Shale	4 ft.
Limestone	10 to 15 ft.

At Turner, two miles west of Argentine, occurs this section:

I.

Limestone, several layers	2 ft.
Limestone, massive oolite	8 ft.
Limestone like the Quindaro "dimension"	2 ft.
Rocky ledge, about	2 ft.
Shale, greenish, with a ferruginous limestone streak in middle, about	8 ft.
Rock, with black chert	4 ft.
Layer limestone, shaly and laminated above	5 ft.

At the quarries one mile west of Edwardsville the section is thus:

J.

Loess, slope, with gravel below	30 ft.
Limestone, five or six layers	10 ft.
Limestone, massive, oolite	6 ft.
Limestone, thin layers, 3 to 5 inches each, and shale partings,	5 ft.
Limestone, two and three layers	7 ft.

Limestone, shale	6 ft.
Limestone, cuboidal blocks to bottom of quarry	15 ft.
Limestone ledge at tank, perhaps	3 ft.
Slope, mostly shale, but probably a hard ledge	30 ft.
Ledge, two or three layers	3 ft.
Shale	6 ft.
Main spillway rock (limestone) at Forest lake	16 ft.
Shale, with a hard ledge	6 ft.
Bottom of spillway rock	4 ft.

It will be seen by a comparison of these various sections that it is not easy to make a generalized statement of the succession of limestones and shales that would be correct for any large part of the county. There has not been a sufficiently extensive examination of the fossils of the strata at any one place to make them a reliable means of identification in other districts. The changing of shale to limestone, and vice versa, is so common that the thickness of a given layer is scarcely any guide to its identification elsewhere. At the old cement quarries at Armstrong a layer of shale which on the southeast side is five feet thick, on the northwest it is diminished to three feet, and is more argillaceous and less calcareous there. The chert beds are more or less persistent, but, notwithstanding their remarkable eastward dip at Armstrong, it ceases to be a guide, by disappearing westerly in the Kaw valley. On the other hand the oolite mentioned in the last three sections is a guide by some of its fossils as well as by its oolitic structure. Myalina Swallovii, Athyris bovidens, and fine specimens of Productus cora are nearly always there. The shells are white lime, and this is characteristic of all the invertebrate fossils in the oolitic limestone, including occasional trilobites (Phillipsia). This oolite is found, besides the places already mentioned, in a cut of the Santa Fe railway in Leavenworth county a few miles northwest from Bonner Springs, and lies below the cement bed at Armstrong.

The section at Argentine shows sandstone below a limestone, and still lower sandstone shales. On the divide, in the middle of the county, between Edwardsville and Pomeroy, sandstone is found at the same level as limestone, as shown in exposures at and south and north of schoolhouse in district No. 36. The contact of sandstone and limestone is not actually seen, but the same horizon is plainly inferable. Nearly the same is seen in a road-cut east of White Church.

The bottom then of the sandstone plateau is certainly irregular. So far the writer has seen no evidence that there is erosive unconformity of the strata. It would appear that by gentle oscillations of level, some deep water formations began to give place to shore-line deposits in the old carboniferous seas. The reverse of this brought on the conditions favorable for the deposit of the heavy limestones at the top of the sandstones in west Leavenworth county and Atchison.

Back in the seventies a boring was made at Wyandotte to a depth of 600 feet, and it was said a three-foot seam of coal was passed through. At what depth there is no record to tell. It is also said that the gas well at Armstrong brick works passed through three feet of coal at a depth of 175 feet. A boring was made in 1887 on the bottom south of the Kaw, at Kansas City, to a depth of nearly 2,000 feet. More recently a shaft was sunk at Rosedale to a depth of 700 feet. The records of these prospectings were, at the time, kept secret, and are now probably lost, so that it is not possible to compare the deeper strata with those in Leavenworth county. Still, as there is no very great dip of the surface rocks, and in Leavenworth comparatively little in the deep seated strata, we may assume that the coal measure formations extend as far down under Wyandotte as in the neighboring county.

THE LOESS.

As in Leavenworth, the surface, except of the river bottoms, is largely composed of the "bluff" or "loess" which forms the yellow subsoil of all the high land of the county, and also is found in a few places beneath the alluvium of the valleys.

DRIFT.

On the bed-rock, under the loess, nearly all over the county, there are glacial boulders and gravel, but in no place is the deposit very heavy. It may be seen up the ravines in the city, up the dairy ravine near Armstrong, on the creek bed at Muncie, in the ravines at Quindaro, Pomeroy, and Connors, as well as in the shallower depressions that hold the headwaters of Wolf creek from Piper to the county line. In only a few places is seen the pasty clay, or hardpan, which the glacier ground out of the terraces it passed over. The marks of the glacier called striae are also scarce. The writer is not sure of any. A few have some resemblance to them; but, though some of the surface limestones are hard, yet water, carbonic acid and iron in the loess mud have been operating so long that the surface under loess is usually softened, and all markings obliterated; and where the loess is gone, the weathering has altered the impressions both in form and direction so that certainty is scarcely possible. Striae may perhaps always be scarce, but some polished surface may sometimes be revealed which will indicate the work of the glacier.

ECONOMIC GEOLOGY.

COAL.

The surface vein of coal which belongs to the sandstone plateau in Leavenworth county does not seem to have been found in Wyandotte county. It is, however, quite possible that a similar vein in nearly the same horizon might be found in any part of the high land of the west and northwest of the county. It would seem that such a vein has actually been proved in the higher part of Kansas City. The erosion has been so great, both before and after the deposit of the loess, that such coal will hardly be found over any large area. Still, as a cubic foot of coal is just about a bushel, a few acres of it 18 inches thick could be valuable, if the cost of getting it is not too great.

It is more to the purpose, perhaps, to discuss the possibility of obtaining deep coal, as at Leavenworth. From what has been said, it is seen that there is no actual evidence on the subject, as the records of borings have either been suppressed or lost.

In Leavenworth county and in southern Kansas the workable coal beds are associated with shales and rocks of sandstone horizons. The Leavenworth record shows no coal or sandstone at the horizon given for the coal at Armstrong (75 feet); still, it might be at the latter place, as the distance from the Leavenworth field is enough to allow for such changes. Again, it is known of many veins of coal that they extend more in their meridional direction than east and west; that is, they are elongated from north of east to south of west. The Leavenworth deep vein is proved to extend entirely across the river bed into Missouri. If, then, a north by east to south by west line be drawn from the known easterly extension of the Leavenworth vein southerly, it would pass through the northwest corner of Wyandotte county, and it is possible that a mine in that region would, at about 900 feet deep, be a paying investment. Again, the Leavenworth record shows thin veins before the main seam is reached, and some veins below. Any one of these might develop thickness in any direction, and there would be a fair chance, even at Kansas City, Kan., for a paying vein to be found at from 600 to 1,100 feet deep. It would certainly pay for a boring to be made to the bottom of the coal measures to determine honestly what there is to be found.

GAS AND OIL.

Both rock gas and oil have been found in the county and north in the precincts of Kansas City, Kan. Several wells—on Jersey creek, the brick yard at Armstrong, and Northrup's mill, etc.—found bodies of gas that were for a long time useful. It does not appear that any great effort was made to develop these wells or preserve them. The gas was found at from 340 to 380 feet deep. It is quite likely there is more of it. Nearer the bottom of the coal measures, as at Neodesha, might prove a better horizon. The well that used to flow on Jersey creek might probably be developed into a paying producer of lubricating oil.

LIMESTONE AND SANDSTONE.

The heavy beds of limestone shown in the sections of the river fronts of this county give abundance for all the purposes for which limestone is used—building, lime-burning, road making, and the manufacture of cement. The more argillaceous shales and limestones may be more plentiful in counties to the west, and they can easily be imported to mix with the limestone here when the business of the Missouri valley becomes once more a growth. There is no place better situated for distributing a large cement product than Kansas City.

The higher parts of the county have some sandstones, but they have not yet been sufficiently exploited to test their value as building stones. Here, and in neighboring parts of Leavenworth county, they are sufficiently well developed to be worth more examination as to their availability for bridges and other purposes.

CLAY.

There are clays and clays. The usual suggestion when the word clay is used is that of a surface deposit easily accessible. In Wyandotte and the other counties of this district there is abundance of this surface deposit, good for making either pressed or common bricks. It may be said that the supply of such clay is inexhaustible by a much larger demand for several generations than has yet been made upon it in this or other counties. The yellow deposit we have described as the loess has everywhere in it beds of workable clay.

There are, however, older beds, sometimes lying deep among the stratified rocks of the coal measures that are more or less argillaceous. They are clay shales. It is these stratified beds of greater age that have been used for making

VITRIFIED BRICKS

for paving. These clay shales of the coal measures contain some iron—sometimes as concretions, elsewhere as streaks or stains; and this iron, in connection with the silica, when properly treated in the making and burning of the brick, gives the glassy luster and hardness that makes the value of this paving material. There is abundance of these shales in Wyandotte county. They are shown in sections B, C, D, and E (ante). In places they are somewhat difficult to reach; but, in the eastern part of the county, almost any long slope having a hundred feet of vertical height would show them under the loess or in the rock outcrops. There are differences of quality, easily determinable by trial. It would appear, from the proved character of vitrified bricks, that they will be a standard pavement of the future. Wyandotte will have its share of this important industry.

Pottery clays are not so common; but they may be found, and that suitable for drainage tiles and sewer pipes is abundant.

In this midcontinental region, far removed from the roofing slates of the mountains, why should not a light roofing tile be manufactured and used? The clays of the river counties are sufficient to roof all the cities of the Mississippi valley.

The metallic base of clay is the metal

ALUMINUM,

which has of late years become familiar in medals, pencil holders, etc. In clay it is mostly in the form of alumina, which is the metal combined with oxygen. Abundant in all clays, the separation of the metal is, as yet, an expensive process. A particular kind of clay, found mostly in two small districts in England, and called fullers' earth, has long been used for cleansing by woolen manufacturers. It has also been used in refining lard, and much of it has been imported for that purpose by the packinghouses of Kansas City. For some time past a bed of surface clay at Turner has been subjected to a peculiar process by Mr. Schwann, in which the percentage of alumina is increased and other matters eliminated. The resultant product has the same effect in the refining of lard that fuller's earth had, and it is now supplanting that material in the packinghouses of this county.

This artificial fuller's earth, containing a large percentage of alumina, may be called, in miners' language, a concentrated ore of aluminum; and it has occurred to Mr. Schwann that it may so be regarded, and that processes akin to the common methods known to the assayer and refiner of the precious metals would reduce the ore and produce aluminum at less outlay than that of the present costly electrical process of extracting the metal from the bauxite. His experiments have been perfectly successful, and there is now lying before the writer a small button of the metal thus made at the Turner smelter from Wyandotte county clay. The only step now to take is the making available, on a large scale, of the proper appliances for extracting the metal from the ore, and Wyandotte county will add another metal industry to the already large one of the silver smelter at Argentine, which has already refined over 9,000,000 ounces of silver.

GRAVEL.

There is, in the Neosho and in other valleys of southeastern Kansas a gravel, not made of rounded pebbles, but of stony fragments, more or less angular, but covered with a brown coat having a vitreous luster. The fragments are made mostly of limestone, but some are chert or flint. But all have the same ferruginous vitrified coating. They make better road material than any crushed stone in Kansas. This gravel is found in some of the watercourses of Wyandotte county, and in places it is found cropping as a thin stratum under the loess, and on some slopes. It has been quarried to some extent near Edwardsville, and search would probably reveal it about Bonner Springs and northward.

The gravels of the drift, composed of quartzite and granite pebbles, are found under the loess in all parts of the county, but probably the deposits are nowhere very thick. The larger boulders of quartzite—the well-known pink and reddish masses—are, however, sufficiently numerous to be worth collecting, and their hardness would make them useful for macadam roads.

MINERAL WATERS.

All springs are more or less impregnated with the minerals over or through which they run. Brown and reddish sands and sandstones and clays have often iron in them; and that will impregnate the water. Water percolating through limestone takes up some lime, and the vegetable matter in some shales supplies iron and sulphur from the decomposition of iron pyrites. The cap of loess also has iron and lime and alum capable of being absorbed by percolating waters; and therefore mineral springs are to be expected in the county. The beautiful rolling surface, the abundance of timber, the softness of the air, and the presence of mineral waters, makes it possible for the county to have more than one delightful health resort.

SOIL.

The loess is the principal subsoil of the county. Its surface, modified by the vegetation it has supported, is therefore the principal soil. It is mostly a marl, and is lighter than clay soils of some regions and in places it inclines to be sandy. The influence of the limestones and shales in forming direct sedentary soils is very limited; but, in the smaller valleys the detritus from the various outcrops has made itself felt in the gumbo and other clay soils of some bottom lands. The bottom lands of the Kaw valley and of the Missouri are largely composed of sandy alluvium. All the soils are fertile and mostly deep.

RAINFALL AND IRRIGATION.

The rainfall of Wyandotte county is abundant for the growth of crops. It exceeds 30 inches per annum. But dry seasons occur here; and the recurrence of drought from time to time in Ohio, New York, and even the western countries of Europe is causing attention to be given everywhere to the suggestion that irrigation may be adopted with benefit in the countries of abundant rainfall, for use at the critical period of crop-growing when "precipitation is procrastinated."

Wyandotte county (and with it all the river counties) is favorably situated for so using water as to ensure crops. The two rivers can be available for the bottom lands by pumping with gasoline or other engines. The topography and geological structure are favorable to the construction of reservoirs, both large and small, for the storage of the run-off waters in all parts of the county. A good example of this is seen in the 39 acres of water at Forest Lake, an artificial sheet shut in by a strong dam a few miles east of Bonner Springs. A pumping plant has been used this year (1894) on the south of the Kaw river near Kansas City.

ATCHISON COUNTY.

TOPOGRAPHY.

The topography of Atchison county is much the same as the other river counties. It has the same steep bluffs to the river; the same narrow openings in the bluffs for the exit of small streams; the same amphitheater forms behind the bluffs; the same rolling upland in the interior of the county. The Stranger does not give so marked a valley; but in one way it is peculiar, its whole depth is in the loess; scarce an outcrop on its sides or stony riffle in its bed to tell of the presence of bedrock. On the other hand, the western part of the county is trenched, by the Delaware and its tributaries, deep into the limestones. In some respects, this valley is much like that of the Big Stranger in Leavenworth county. The loess is over most of the county, and gives the rounded forms and smooth slopes to the topography of the central plateau; and there is scarcely any outcrop of the bedrock from near the Missouri bluffs to the valley of the Delaware.

GEOLOGY.

The bedrock of this county is of the coal measures. The connection of particular strata with those of the neighboring counties has not been worked out; but it would seem that some of the coal measures limestones might be traced through from Leavenworth county. At the mouth of Whiskey creek, a mile south of the city of Atchison, this section overlooks the valley:

Clay, slope.	
a. Dimension limestone	18 in. to 2 ft.
b. A whitish brick shale	4 to 6 ft.
c. A quarried limestone, somewhat irregular	15 to 20 ft.
d. Black shale	4 ft.
e. Dimension rock	2 ft.
f. Another quarried rock below	2 ft.

There is here a resemblance to the Leavenworth city section; but if the two dimension rocks are the same, it would indicate the absence of the whole series of sandstones and sandy shales of the Wyandotte-Leavenworth plateau. It is more likely that (a) represents one of the limestone ledges below the plateau that are not there of the "dimension" character; and that the sandy shales are hidden above under the loess. A mile further south this outcrop occurs also near the Missouri river:

Slope.	
Quarried limestone	10 ft.
Shale	10 to 20 ft.
Rock (limestone)	10 ft.
Clay shale	15 ft.
Coal	1 ft. 6 in.
Black shale	6 in.
Clay (shale)	10 ft.

The shale that has been used for several years southwest of the city, in the manufacture of vitrified bricks, is under a bed of limestone, and is probably one of the layers shown in one of the river sections; but concretions of limonite found in the original brick-bed are not so conspicuous elsewhere. Away from the river the sandstone shows and is given in the following record of a deep boring, made several years ago by the city:

Record of strata passed through in Atchison deep boring:

	Thickness of strata.	Total depth.
Sandrock	24	24
Limestone	10	34
Red shale	10	44
Soapstone	5	49
Limestone	2	51
Soapstone	20	71
Sandrock	5	76
Soapstone	64	140
Limestone	2	142
Soapstone	90	232
Limestone	2	234
Black shale	1	235
Soapstone	7	242

Limestone	4	246
Black shale	5	251
Soapstone	12	263
Limestone	7	270
Soapstone	12	282
Limestone	8	290
Soapstone	10	300
Sandrock	3	303
Limestone	30	333
Soapstone	15	348
Limestone	8	356
Sand shale	4	360
Limestone	3	363
White shale	12	375
Soapstone	4	379
Limestone	38	417
Dark shale	5	422
Green shale	8	430
Limestone	8	438
Soapstone	6	444
Green shale	10	454
Limestone	3	457
Dark shale	20	477
Limestone	2	479
Gray shale	6	485
Limestone	27	512
Gray shale	9	521
Limestone	21	542
Dark shale	2	544
Limestone	21	565
Flinty limestone	3	568
Soft sandrock	30	598
Soapstone	45	643
Soapstone	22	665
Yellow clay	8	673
Red and purple shale	5	678
Limestone	5	683
Red and purple shale	20	703
Conglomerate	17	720
Limestone	4	724
Conglomerate	71	795
Limestone	4	799
Soapstone	11	810
Limestone	3	813
Soapstone	20	833
Limestone	4	837
Conglomerate	* 20	867
Limestone	2	869
Soapstone	36	905
Limestone	5	910
Soapstone	12	922
Limestone	5	927
Soapstone	53	980
Limestone	4	984
Soapstone	18	1,002
Sandrock	23	1,025
Soapstone	24	1,049
Sand shale	64	1,113
Sand rock	4	1,117
Sand shale	87	1,204

There is an inaccuracy in this record at the item marked (*). It is not possible from any information I have, to correct it. It may be that addition of errors in measurements of strata sum up ten feet. There is a term used several times in the record that is of doubtful intepretation, as drillers do not use it in its strict technical sense. It is the word conglomerate. It is more than probable that it is here used for a dark shale containing hard nodular masses which contain lime crystals and iron as limonite or pyrite. The term soapstone is the drillers' usual designation of lavender-colored soft shale.

It does not appear that any coal was found in the boring; but the sand horizons of the lowest 200 feet suggest that they are near the bottom of the coal measures, where the chance for coal is greatest. It is a matter of regret that the drill did not continue its work until the examination of an expert decided that the coal measures had been entirely passed through.

CRETACEOUS.

I have already referred to the fact that the loess covers the greater part of the county. It in places has some sand and gravel, and boulders are occasionally seen at the bottom of it; but there seems to be no other formation in this or the neighboring counties between the age of the coal measures and these pleistocene deposits. There is, however, one fact in Atchison county that seems to point to the existence, at no great distance from this region (perhaps in this county itself), of cretaceous rocks once overlying the coal measures.

Arrington Springs, in the western part of the county, comes out of the debris that partially fills a preglacial valley. It is a chalybeate spring, and its iron is undoubtedly derived from the fine gravel, or coarse sand, through which it flows to the surface. The deposition of the coarse sand is probably of the glacial period, though it may be older. An examination of this sand suggests at once to any one familiar with the cretaceous formations, that it is the debris of the ferruginous Dakota sandstones. That it would keep that Dakota facies improbable if it had been transported far from place of degredation. I have seen such Dakota debris sand in the lower valley of the Smoky, where the propinquity of the original sandstone is not a matter of conjecture. Less than 20 miles further west than Arrington, I have found sharks' teeth and fragments of Ammonites in the glacial gravels, which could not have been transported far from their original Mesozoic beds, but such debris as these Arrington sands and such well preserved fossils are now all the evidence to suggest that a great thickness of strata once covered the carboniferous beds that have now only a covering of pleistocene or more recent deposits.

PLEISTOCENE.

It has already been stated that there is a covering of loess over most of this county. Its texture and general appearance are not unlike those in the other river counties. But there seems a difference in all these from that on the east side of the river, which is worthy of more attention than I have been able to give to it. In the Stranger valley the loess hides all bedrock. Wells over 50 feet deep do not reach the bottom of it. It is mostly a clay; but to the west, near the Jefferson county line, there is sand and gravel.

The occurrence of boulders has not been sufficiently observed to warrant any description of the morainic deposits which are mostly buried under the loess.

ALLUVIUM.

The present valleys, as well as the upland depressions, have some recent alluvial formations of sand, gravel, and joint clays and humus, the product of the present agencies of running water, wind, rain, and frost on the older formations. But what are properly called bottom lands are of very limited extent in this county. There are here and there some soils that are black like humus soils, but probably owe their color and character to black shales of the coal measures, out of which they were formed in or soon after the ice age, and are not, therefore, true modern alluvia as they seem to be.

ECONOMIC GEOLOGY.

COAL.

While the borings made in the county have not revealed the presence of deep-seated veins of coal, yet the one seam near the surface, indicated in one of the sections given on a previous page, has turned out to be of great economic value as a local fuel near Atchison. It is also quite probable that it may be discovered, or another near the same horizon, further inland, where by means of shallow shafts, it may be cheaply lifted to the surface. Shallow borings in different parts of the county would early determine this. The thin seam at Arrington will probably not be found thicker if traced any distance.

LIMESTONE.

The bluffs on the river, and outcrops in the west part of the county, furnish abundance of this material both for burning and for building. It has been so far but little exploited.

CLAY.

The loess everywhere yields good material for common or pressed bricks; and, as population increases, the building of brick houses and the making of the bricks will constitute an important permanent industry.

SHALE.

It was Atchison that first made vitrified bricks in Kansas. These are made of coal-measure shales, of which there is abundance down the river front of the county. The selection of the best qualities and the proper manipulation of these shales constitute an art in which some citizens of Atchison are now experts. The miles of streets paved in their own city and the millions of bricks exported for the streets of other cities, are in evidence as to the value of this pavement, which is destined in the future to hold an important place in the comfort and sanitation of urban communities. The enterprise that began the industry will always keep a large share of it in Atchison county.

Terra-cotta ware and other molded forms of blocks are among the future products of these clay shales in the river counties. Why not tiles for roofing?

MINERAL WATERS.

Small seepings of water, more or less mineralized, come from the gravels and sands in various places under and in the loess. It is quite possible that some time others of more volume may be obtained. In the meantime Arrington springs furnishes a valuable iron water, and the surroundings are such as to make it, in times of denser population, a pleasant health resort. Its elevation of over 1,000 feet above sea level is another fact of value.

SOIL.

The soil is the last made geological product. Most of the soil of this county is formed of the loess by the action of the vegetation itself. The loess is the subsoil. Some of it is heavy from the prevalence of clay, but elsewhere a greater proportion of sand makes the soil more tractable. In either case it is fertile. Where shales are near the surface, gumbo soils of more or less tenacity have been found, but the areas of such soils are limited. The lighter soils of bottom lands also occupy but a small part of the county. The soil is probably the most valuable mineral product of the county. With the proper treatment it will grow all the products of the region.

N. B.—Since the foregoing was written, the writer has had the privilege of reading two papers which, with illustrations, were submitted to the Kansas Academy of Science and is allowed to make excerpts therefrom. They give definiteness to one or two points mentioned in the foregoing pages.

Prof. E. B. Knerr, in describing the Atchison coal field, says: "The vein of coal lies between two veins of brick shale or soapstone, as it is sometimes called, the material from which the excellent Atchison vitrified brick is made, and it is the purpose of the Donald firm (the coal company) to operate a brick plant in connection with the coal industry. The vein of shale over the coal is 25 feet thick." The coal measures 16 inches thick and its value, as indicated by chemical analysis, is "on an equality with the best from any other part of the state." The analysis is as follows:

Ash	7.30
Water	3.46
Gas	36.84
Coke	52.38
	99.98

The coal is worked from the outcrop which is two miles south of the city, and has been continuously worked since August, 1893. The area that has been excavated is 700 by 400 feet, which gives a total output of over 373,000 bushels, or about 15,000 tons. This is no mean addition to the resources of the county. Prof. J. M. Price of Atchison has worked out the succession of the formations in the neighborhood of the city completely, and so gives the coal horizon its proper place. The geological succession is thus indicated by Professor Price:

Boulder drift from 0 to	50 ft.
Fusulina limestone, about	3 ft.
Shale	10 ft.
Limestone	4 ft.
Shale	4 ft.
Sandstone	6 to 8 ft.
Brick shale	20 ft.
Limestone	4 ft.
Shale	20 ft.
Limestone	8 in.
Shale	4 ft.
Cap limestone	20 ft.
Slate (shale)	3 ft.
Limestone, heavy jointed	1 ft. 9 in.
Shale	12 ft.
Limestone	10 ft.
Shale	25 ft.
COAL	1 ft. 4 in.
Shale, to river level	30 ft.
Total	231 ft.

DONIRHAN COUNTY.

TOPOGRAPHY.

The third county in the state for "smallness," Doniphan, has a remarkably extensive river front. It has the same rolling loess topography as the other river counties, and the same limestone and loess bluffs to the river.

GEOLOGY.

The geology is similar to that of Atchison and Leavenworth counties. The bedrock, limestone, or shale, is of the coal measure period, and the cap of loess and the lower gravels and boulders are of the ice age. It was intended to have given all the river counties as full treatment as that given to Leavenworth county, but lack of means made this impossible, and Doniphan county is only mentioned to show that a good intention has not been carried out, and to suggest that, if a state survey were set on foot, this fruitful corner of Kansas would have the attention that its position as a river county demands.

In view of the fact that the elevations above sea level of Kansas City, Leavenworth, and Atchison, are usually given as those of the railways that skirt the river, the following table showing elevations inland for comparison, will be of interest:

ELEVATIONS ABOVE SEA LEVEL.

Riverside elevations:	
White Cloud	848 ft.
Atchison	795 ft.
Leavenworth	766 ft.
Kansas City, Kan	750 ft.
Kansas City, Mo	750 ft.
Argentine	750 ft.
Armstrong	757 ft.
Bonner Springs	786 ft.
Linwood	791 ft.
Inland elevations:	
Severance	904 ft.
Troy	1,097 ft.
Effingham	1,137 ft.
Pleasant Ridge	1,082 ft.
Leavenworth waterworks	1,120 ft.
Piper	976 ft.
Bethel	1,017 ft.